

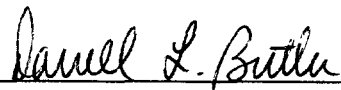
***The Role of Attention in Perceptual Interpretations of  
Reversible Figures***

***An Honors Thesis (ID499)***

***by***

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## The Role of Attention in Perceptual Interpretations of Reversible Figures

Reversible figures are stimuli that appear to alternate spontaneously between multiple perceptual interpretations or orientations. Some of the more famous examples of reversible figures are the old-young woman (Boring, 1930), the duck-rabbit (Jastrow, 1900), and the rat-man (Bugelski & Alampay, 1961).

The first major theory proposed to explain why these reversals take place was a neural satiation theory (Kohler & Wallach, 1944). According to this theory, different sets of neurons accompany the different interpretations of the reversible figure. One set of neurons fires and the viewer sees one interpretation of the figure. This set of neurons fires until it becomes "satiated." At this time, another set of neurons starts firing and another interpretation of the figure is seen by the viewer. This continues until the first set of neurons recovers and can begin firing again. The reversals occur spontaneously and are completely controlled by neural processes. Kohler assumed that neural recovery takes longer than neural satiation. Because of this assumption, he posited that perceived reversals over time should increase.

There have been numerous studies that have supported the neural satiation theory. Many researchers have found evidence that perceived reversals over time do increase (Brown, 1955; Cohen, 1959; Spitz & Lipman, 1962; Long, Toppino, & Kostenbauder, 1983). Following the presentations of the reversible figure with a brief period of rest tends to slow down the rate of reversals (Spitz &

Lipman, 1962). It is suggested that this slowing occurs because the neurons are allowed to recover from their fatigue during the rest period.

There are also many studies that do not support the neural satiation theory. Several studies have found evidence that viewers have some measure of control over the number of perceived reversals they obtain. Pelton and Solley (1962) found that reversals were obtained every 2.5 seconds when subjects were instructed to switch interpretations back and forth as quickly as they could, whereas reversals were obtained every 6.0 seconds when subjects were instructed to hold each interpretation of the figure as long as possible. The number of reversals did not increase significantly over a period of three minutes, as the neural satiation theory would have predicted. Also, in a study by Girgus, Rock, & Egatz (1977), it was found that subjects did not report reversals for some well-known reversible figures if they were not informed beforehand of the nature of reversibility or of the different interpretations of the stimuli. This indicates that reversibility seems to require knowledge of the alternative interpretations of the stimuli.

Another major theory that attempts to explain the nature of reversibility is the learning theory (Ammons, 1954). According to this theory, people first have to learn the different interpretations of the stimuli and then learn how to obtain reversals. Learning theory predicts that more reversals will occur with spaced exposure rather than massed exposure. It also predicts

that moderate rest periods should not have a great effect on reversal rates because little forgetting should occur during that time (of about 5 minutes). Spitz and Lipman (1962) rejected learning theory because these predictions have been contradicted by findings from other studies.

An alternative theory has been proposed by Reisberg (Reisberg, 1983; Reisberg & O'Shaughnessy, 1984). He argues that reversals result from shifts in attention. Reisberg and O'Shaughnessy gave evidence for this theory by having subjects count backwards (an attention-distracting task) and report reversals. This procedure increased the latency of reversals in subjects. These findings could be attributed to other explanations, but they are consistent with Reisberg's attention theory.

There is other support for the hypothesis that attention processes are a factor in reversibility. Peterson and Hochberg (1983) found that subjects can partially control their perceived orientation of a Necker cube when instructed to maintain one orientation or the other. They found that stimulus features near the viewer's fixation point and their perceptual task (to hold one interpretation or another) both had strong effects on reported reversals. This indicates that reversibility can be brought under voluntary control. Tsal and Kolbet (1985) showed that by directing subjects' attention, they could predict which interpretation of the reversible figure would be seen by the subjects.

Rock (1975, 1985) argues that viewers use bottom-up perceptual processes to achieve first interpretations of objects. The

observer constantly accepts information from the environment as he tries to understand what a given stimulus really represents. Reversible figures offer more than one initial interpretation of the stimulus, and it causes the perceptual system to alternate between the two acceptable interpretations in a continual effort to perceive the "correct" one.

It is our contention that both attentional processes and "bottom-up" perceptual processes affect reversibility. Stimulus cues or environmental cues such as shading (bottom-up processes) should have a strong effect on the first interpretation of a reversible figure and probably reversal rates. Subjects should also be able to use their attentional processes to hold a certain interpretation of a reversible figure.

A recent study by Peterson and Hochberg (1983) provides support for this two-factor theory of reversibility. They did a study using the Necker cubes. They were testing the strength of environmental cues on reversible figures. They asked their subjects to stare at a biased or unbiased intersection (the biased intersection had shading on it to provide a depth cue) and the subjects were asked to try to hold either the horizontal or vertical line at the specified intersection "forward" on the object. They found that subjects were able to hold certain lines "forward" on the object and that depth cues had a strong influence on the subjects' perceived interpretations of the location of the lines. When subjects were asked to fixate their eyes on the unbiased intersection (the intersection with no shading cue around

it), the depth cues at the biased intersection exerted considerably less influence over the subjects' responses.

Unfortunately, Peterson and Hochberg (1983) confounded inter-cue distance with cues. In other words, were their subjects staring at intersections that were equidistant from the other cues in the stimuli? To combat this confounding in the study reported below we manipulated the size of our stimuli so the environmental cues were at varying distances from the subjects' focal points. This way, we could study the effects of the localization of environmental cues on perceived reversals. Our subjects were shown three different sizes of the Necker cube. We expected to find that size had an effect on the number of perceived reversals. We theorized that it should be easier for subjects to hold interpretations at the large size because there would not be as many environmental cues available in the immediate vicinity of the designated corner to distract the viewer's attention. We would predict that there would be more reversals occurring in the small size. These effects would occur because of the interaction between attention and environmental cues. Subjects should be able to exert more attentional control to hold a certain interpretation if there are fewer environmental cues around their focal point distracting or drawing their attention. Subjects would be predicted to exert less attentional control at the small size (report more reversals) because there are more environmental cues right around the focal point to draw the viewer's attention away from the task at hand.

## METHODS

Subjects. Subjects were 18 volunteers from the Ball State University Department of Psychological Sciences research participant pool. Based on self-report, all subjects had normal or corrected 20/20 vision.

Stimuli. There were three drawings differing only in size made using black ink on tracing paper. Then one or two layers of blue plastic were affixed to the figure to create light and dark shading on the stimuli. Slides were then made of the stimuli. They were photographed in four different orientations: upright, 90 degrees, 180 degrees, and 270 degrees clockwise rotation from that shown in Figure 1. They were also drawn with three different sizes -- small, medium, and large. As projected in the experiment room the stimuli were 5.75, 10.625, and 20.25 degrees of visual angle respectively. A second, different group of slides was created for location cue slides. These had just a dot on each slide to indicate where a corner would be on a corresponding reversible figure slide. Multiple copies of these slides were used in this study.

Insert Figure 1 here
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Apparatus. A slide projector was interfaced with an Apple IIE computer. A specialized program was written for this experiment. The "B" key on the computer keyboard was marked "front" and the "6" key on the keyboard was marked "back." The computer was programmed

to advance the slide projector and to record which keys were pressed and how much of each 60 second trial was spent on each key. A microphone was also affixed to the top of the computer display terminal, but it wasn't in working condition. The slide projector screen measured 7 feet x 5 1/2 feet. It was located 9 1/2 feet away from the projector.

Procedure. Subjects were run one at a time. When subjects arrived at the laboratory, they were brought into the experiment room. They were seated in front of the computer and told there were two parts to the experiment. They were then presented with written instructions explaining the task to them. The words, "front" or "back" would appear on the computer screen in front of them. They were to repeat the word out loud and simultaneously depress the key on the computer that corresponded to the word they saw on the screen. They were to make their responses as quickly as possible and they were told that their reaction times would be measured. They made a total of 100 responses. This was to get them used to responding correctly to the concepts "front" and "back" so they wouldn't have to look at the keyboard in the next part of the experiment. They were told to come get the experimenter in the next room when they were done with the task.

When the subjects were finished with their first task, the experimenter asked them to read the next set of written instructions very carefully. The experimenter then went over the instructions with them until they fully understood their task (this took approximately 10 minutes). The subjects were shown the



figures that appear in Figure 2, 2A, and 2B. They were given the definition of reversible figures and asked to look at these figures in the instructions. They were told that they would be shown a cue slide that would show them where to fixate their eyes. They were to focus on this cue until another slide came up on the projector screen. On this slide would be an object with a corner located where their eyes had been fixated from the cue slide. They were to look at this corner and immediately decide whether the corner looked like it was in the front or the back of the object. They were asked to make this response immediately on the computer keyboard without taking their eyes away from the designated corner.

Their task was to try to hold the corner in the front of the object for as much of the time as possible, but they were to report whenever the corner appeared to switch to the back of the object by pressing the appropriate key. They were informed that some subjects get many reversals while some report none at all. They were told that they would get a 1 minute interval between stimuli to rest their eyes. Each reversible figure was on the projector screen for 1 minute. Each subject saw 6 stimuli (2 small, 2 medium, and 2 large with a front and a back shading bias at each size) that were all in the same orientation. They were not told how many slides they would see during the experiment. The slides were in a random order determined by a computer randomization program. Each subject saw a different random order of the slides.

There were four groups of subjects. Each group differed in the orientation of the Necker cube they saw. Subjects were

randomly assigned to groups. The four different orientations were presented previously in Figure 1.

Insert Figure 2 here
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## RESULTS AND DISCUSSION

Our dependent measure was the percentage of time that subjects reported that the corner they were instructed to hold in the front of the object appeared to be in the front of the object. An analysis of variance (ANOVA) was conducted with one between-subjects variable (orientation of the cube) and two within-subjects variables (location of designated corner and size of the cube). The location of the designated corner was determined according to the shading bias. Cell means are shown in Table 1. Our sample size was too small ( $N = 18$ ) to obtain statistically significant effects for position, size, or orientation on the perceived number of reversals. There were also no statistically significant interactions among any of the variables. However, there were certain patterns that emerged which would probably be significant given a larger number of subjects.

First of all, attention does appear to play a large part in the perceptual interpretation of reversible figures. Chance would predict that subjects would spend 50% of their time on the "front" key and 50% of their time on the "back" key. This was not the

case. The subjects were able to spend well over 50% of their time holding the designated corner in the front of the object. They spent 75.32% of their time on the "front" key -- a 25.32% increase over the expected 50%. This is a significant increase. This supported the hypothesis that subjects would be able to exert attentional control to hold a certain interpretation of the object.

The data also indicates that environmental cues/shading do matter. It was more difficult for subjects to hold the designated corner in the front of the object when the shading biased them to see the corner in the back of the object (their mean time spent on the "front" key was 76.72% when there was a "front" location bias and 73.92% when there was a "back" location bias). They were still able to hold the corner in the front of the object over 50% of the total time, even when there was a "back" location bias.

In addition, the data did seem to indicate that there was a small effect of size on the number of perceived reversals. However, the effect was not what we expected. We had predicted that the large size would be the easiest at which to hold the corner in front because there would be fewer environmental cues around to distract the attention of the viewer. It was somewhat easier to hold than the small size, but there was not a big difference. Subjects spent 74.59% of the time on the front with the large cube and 72.77% of the time on the front with the small cube. We predicted the largest number of reversals would occur at the small size because the designated corner would be surrounded by environmental cues (shading, lines). This is not what happened.

Instead, the borderline effect we saw indicated that the medium size was the easiest size at which the subjects could hold the interpretation. Subjects spent 78.60% of their time on the front key in this condition. One subject shed some light on this finding when she mentioned that if she was trying to hold just the corner in the front of the object, it was easier at the large size, but if she was trying to hold the whole interpretation of the figure in the forward position by staring at the corner, she found it easier at the small size because she could see more of the whole figure. These opposing methods of holding the corner forward could easily have cancelled each other out and that's why the medium size had the longest mean time spent on the "front" key. This is just one possible explanation for this finding.

There was an effect found with the interaction of shading and size. (See Table 2) There was approximately a 3% difference in means at each size consistently, and the "back" bias was the lower mean at each size.

Orientation of the cube did seem to influence the perceived number of reversals. Subjects found it easier to hold the corner in the front of the object when the cube was in orientation A or D (subjects spent 79.48% of the time on the front). They had a more difficult time holding it in the front when the cube was in orientation B or C (subjects spent 71.17% of the time on the front -- approximately an 8% difference). We propose that this orientation effect occurs because orientations A and D are in a "sitting" position. In other words, you see the top of the cube.

Orientations B and C are in a "hanging" position. You see the bottom of the cube when you look at these stimuli. This orientation effect was suggested by Butler (1988). He found that there are context effects for objects that appear to be "compressed" (or in a "sitting" position) but not for objects supported by "tension" (or in a "hanging" position). Because we normally see objects in our surrounding environment in a "sitting" position (we see the tops of them), it is easier to see the cubes in this perspective, regardless of their shading bias. People do not tend to see the bottom of objects in their environment. Perhaps this made it difficult to see the cubes in the "hanging" position.

There was also a small interaction effect of shading and orientation. (See Table 3) In the "sitting" positions (A & D), environmental cues had a larger effect than in the "hanging" positions (B & C). This lends support to the research by Butler (1988) about context effects being greater in "compressed" objects ("sitting") than in objects supported by "tension" ("hanging").

One other finding that should be mentioned was the fact that some of our subjects were able to successfully hold the corner at the front of the object for the entire time (1 minute) without ever getting a reversal. This occurred when the shading was consistent with the interpretation they were trying to hold. This seems to be fairly strong evidence supporting the fact that people do have some measure of control over the number of reversals they perceive and that their attention can affect these reversals. Also, the

data supports the fact that environmental cues do influence the perceived number of reversals slightly, but they can also be ignored if enough attention is exerted.

At this point, we don't know whether there is an interaction between the effects of environmental cues and attention, or if they operate independently of one another. This would be a good implication for further research. How do we decide if an interaction exists (they depend on each other) or if they can operate independently? Perhaps the introduction of a new variable into the instructions would help get at this answer. For example, subjects could be asked to hold the corner in the back of the object on some stimuli or asked to try to get as many reversals as they possibly can. These variables might be able to tell us more about the role attention plays in the perceptual interpretations of reversible figures, and it also may help us to answer the question of whether the variables operate on an interaction basis or if they operate independently. Further research needs to be done in this area with a larger number of subjects to find out exactly how large of a role these variables are playing in the interpretations of reversible figures.

TABLE 1

Cell Means for Average Time Spent on "Front" Key

		A	B	C	D
position/bias size					
front	small	78.33	70.00	70.40	78.00
front	medium	89.00	69.80	73.60	87.50
front	large	91.17	65.00	74.80	73.00
back	small	73.83	72.60	64.00	75.00
back	medium	85.17	69.20	75.00	79.50
back	large	79.17	77.60	72.00	64.00
		82.78	70.70	71.63	76.17
Total # in group		6	5	5	2

TABLE 2

Interaction of shading and size

	Front	Back
Size		
small	74.18	71.36
medium	79.98	77.22
large	75.99	73.19



TABLE 3

## Interaction of Shading and Orientation

	Front	Back	% Difference
<hr/>			
Orientation			
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A	86.17	79.39	6.78
B	68.27	73.13	4.86
C	72.93	70.33	2.60
D	79.50	72.83	6.67
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## FIGURE CAPTIONS

Figure 1: Necker cube and the four (4) different orientations seen by subjects.

Figure 2: Necker cube and the two (2) different ways it can be perceived.

FIGURE 1

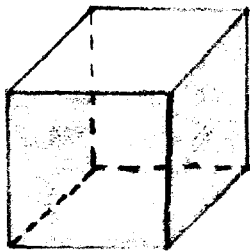
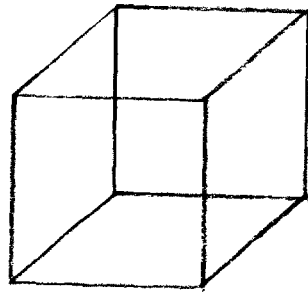


Fig. A

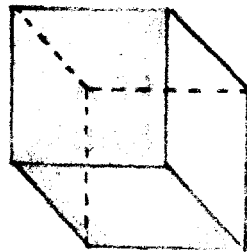


Fig. B

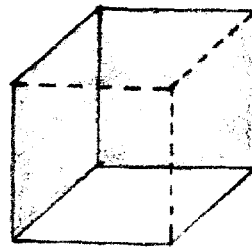


Fig. C

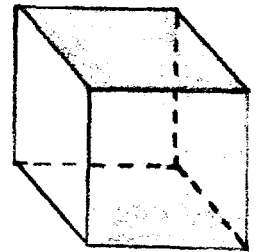


Fig. D

FIGURE 2

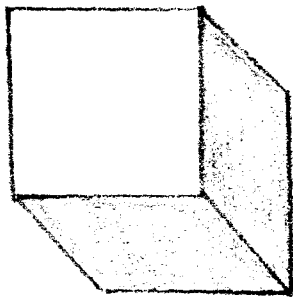
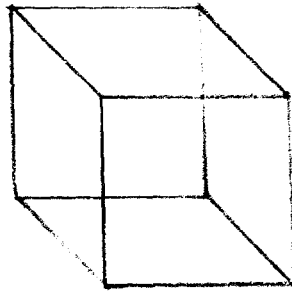


fig. 2A

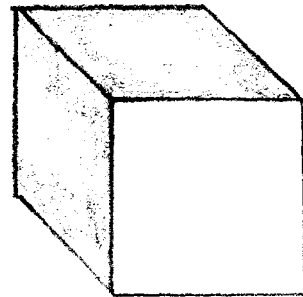


fig. 2B